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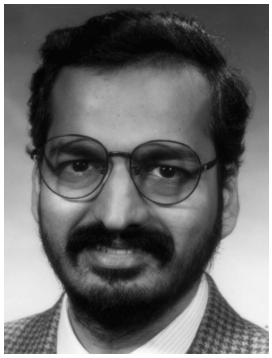

PERSONAL ASSISTANTS

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"Have your assistant call my assistant—they can make the arrangements."

Our business cards used to list only our phone numbers. When fax machines became popular, we added our fax numbers. Now, our business cards also carry our e-mail addresses and our home page URLs.

What's next?

It could be the network addresses of our personal assistants. These assistants will take care of our schedule and may even represent us in many situations. And with a good enough assistant, we might not need all those other numbers on our business cards.

Already there are simple personal agents to help with some of our shopping (see, for example, **Firefly**, **AgentSoft's Agent Builder**, or **CDnow's Album Advisor**). There are agents to track stocks in our portfolios, advise us on how to use particular software products, and arrange meetings within corporate workgroups. However, none of these agents takes more than one aspect of our activities into account, nor do they adapt easily to our preferences.

The Personal Assistant Advantage

Personal assistants, on the other hand, are agents that can represent individuals on the Web. They help users in their day-to-day activities, especially those involving information retrieval, negotiation, or coordination. A personal assistant might schedule a meeting and then, based on the meeting location, find the nearest babysitting service or the ATM with the lowest transaction fee.

A personal assistant differs from a personalized search program or e-mail filter in that it is inherently network-based, interactive, and adaptive. Personal assistant applications are also general-purpose and long-running.

Recall that agents are autonomous, yet aware of and able to interact with other agents. They can perceive their environment, reason, and act. For personal assistants, the reasoning is about schedules, about user preferences and the preferences of other users' assistants, and about reputations. Thus personal assistants inevitably participate in a multiagent system.

So what can personal assistants do? In addition to managing our personal calendars, they can communicate with other personal assistants to schedule telephone, video, or in-person conferences. They can find people to perform a needed service for us. For example, if we are traveling and need a dentist or physician, our assistants can help identify one. For people we already know, they can find the best time and means to contact them for a specified purpose. Our assistants can help us in buying or selling by gathering information about a particular market (such as local real estate) or potential buyers, contacting vendors or informing buyers of goods and services, negotiating terms, concluding sales, arranging deliveries, and ensuring service and support. They can protect us from unwanted telephone calls and e-mail messages. Our assistants can also remember the quality of our interactions and build local referral lists for future use.

Interaction Framework. The increasing popularity of handheld organizers and schedulers has generated interest in online business cards, a form of database record. These cards can be transmitted over an IrDA (infrared) link or attached to e-mail. The current generation of cards carries just basic information, much like traditional printed business cards. However, they could become the basis for interactions among personal assistants. In a fairly simple framework, the business cards would contain information about how and when their owner can be contacted. Personal assistants would then publish or otherwise distribute the business cards, via a process only slightly more sophisticated than users handing them out at a conference or cocktail party.

Negotiation. Even in settings where the agents are autonomous—or perhaps we should say, *especially* in settings where the agents are autonomous—things are rarely as cut-and-dried as the foregoing examples might suggest. Like most other things in life, the decisions and actions of agents are eminently negotiable. Therefore, personal assistants must be able to negotiate on behalf of their users.

For example, a user should normally receive a call on an address only if his or her card specifies that the call would be acceptable. However, if the caller needs to reach the user at a time and address that the card does not specify, the personal assistant needs a

way to negotiate, based on the urgency of the incoming call, about whether to alert the user or not. To carry out this negotiation, the assistant could be programmed at first to be flexible, but to learn from their user how to balance the thresholds of urgency (of the caller) and convenience (of the callee).

Profiles

The data structures that underlie the functioning of personal assistants are called *profiles*. On a personal computer, an operating system maintains profiles of users' preferences for the appearance of their desktop. In personal assistant applications, the users and their assistants must build profiles of other users. Since computational agents lack the common sense and experience of humans, the design and construction of profiles is crucial to their operation.

To enable interaction and negotiation among users in an open environment, a profile should support the following requirements:

- *Heterogeneity*. Assistants must be able to interact with assistants from different vendors.
- *Autonomy*. Assistants must behave as their users wish, not according to the dictates of other users or assistants.
- *Idiosyncrasy*. Profiles should include details relevant to a user or class of users.
- *Multiple perspectives*. Each user can maintain an individual perspective about someone else's agent, and disagree with others about any substantive details of the profiles.
- *Sharing*. When appropriate, assistants should be able to disseminate the knowledge and opinions of their users.

Personal assistants meet these requirements through mechanisms that define reputations, roles, situations, and contexts.

Reputation. In an open society, disseminating the personal and professional reputations of individuals can be an important factor in negotiating and concluding agreements. This is especially true when legal remedies to breaches in trust are difficult to determine and impose. Given a choice, everyone would like to deal with someone of good reputation. However, getting information about a person's reputation might not be easy. If easily shared, the profiles maintained by individual personal assistants could help users to determine an individual's system-wide reputation.

Roles. People often play more than one role in society. Users' business cards can be structured into different aspects that capture information about these roles. Aspects help refine the knowledge represented in a business card. Users may specify preferences for each of their roles. For example, a scientist in a small company may also have the role of building liaison. However, the user prefers to receive building complaints only late in the afternoon and only when in the office, and can specify these preferences accordingly. Each aspect specifies which role it corresponds to and how to reach the user regarding that role. A user does not have to specify aspects as a default top aspect is defined for every card.

Situation. A user's situation is the physical or environmental circumstances in which the individual operates. Situational elements that arise naturally include geographical location, local time, urgency, convenience, and availability.

Some situational elements vary only if the user is mobile. An effective assistant should be aware of the user's situation, which can be determined in several ways. Elements such as location and time can simply be read from a monitoring device, while convenience and availability are largely determined from the user profile. An assistant would have to use more careful reasoning and inference to determine elements like the urgency of a message or the unexpected unavailability of the user.

Context. This feature defines the aspects of meaning and processing that derive from where the given functionality is being invoked. This is context roughly in the programming language sense of the term. For instance, in different contexts, the behavior of assistants can exhibit different levels of flexibility. Contextual matters tend to be highly specific to the given user's needs.

SYSTEMS OF THE BIMONTH

A number of interesting projects deal with the individual capabilities of personal assistants.

NetSage's personal agents, called Sages, are based on rule-based expert system technology. Sages are animated software characters that reside on a user's desktop and interact with Web servers on the user's behalf. They take Web information and present it in a user's preferred format, or provide user preferences to servers to obtain recommendations. They can be used for shopping, teaching, and selling. They are still limited to client-server interactions, and are not social enough to deal with Sages of other users.

IBM has developed an important new technique, called MemoryAgent, by which agents can build memories about each other. In this approach, the assistant behaves partially like an expert system of yore in giving advice, and partially like a personal assistant who learns the user's preferences and helps convey the knowledge among the users. A physician's assistant and an e-mail assistant have been implemented.

Wildfire offers an assistant that helps with e-mail, telephones, and maintaining contacts.

Check them out!

Some integrated personal assistant systems are being developed as research prototypes. The ones we know of are still proprietary. If you know of any publicly declared projects, please contact us with details.

RELATED WORK

There has been much research on different aspects of personal assistance. Sandip Sen and associates evaluate strategies for scheduling meetings in the face of changing requirements.[1] Kautz and colleagues at Bell Labs use a system for scheduling meetings as a testbed for agents.[2] Through their work they have developed a number of requirements for the successful use of agents as assistants. Rich and Sidner describe a system in which agents interact to assist users with travel plans.[3]

An example of the use of profiles in deploying personalized Web services is the One-to-One development tool from BroadVision Inc. The tool uses both stored and learned customer profiles in combination with business rules to determine what information or services to present.

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Profile Management

For profiles to prove useful they must be kept up-to-date and coherent. This requires careful attention to systems for disseminating profiles and propagating updates.

We envisage personal assistance as a ubiquitous application involving millions if not billions of users. For something so grand in scale, an open architecture that permits a demand-driven style of propagating information would be the way to go. In creating such an architecture, it is important to consider how online business cards are created, and how users and personal assistants are made aware of them. In addition, there should be a central location to send update notifications when users change their cards. Assistants should also be able to validate the cards of other assistants involved in an activity, and if necessary, update their profiles of each other.

Early studies have shown that personal agents will be easier to use if they appear and behave more like human assistants. In a previous column we reported on the embodiment of emotion in agents.[1] Additional work has focused on the use of animation and gestures to give agents familiar, human-like characteristics and synthetic personalities.[2] This work has made progress in producing believable, engaging, synthetic persona that exhibit emotion and intelligence.

URLs for this column

AgentSoft's Agent Builder • www.agentsoft.com/
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Net Perceptions • www.netperceptions.com/
NetSage • www.netsage.com/
Wildfire • www.wildfire.com/consumer/

Standards

Relevant standards activity includes the vCards and vCalendars work of the **Internet Mail Consortium**. These standards provide a low-level framework for the exchange of contact information and schedules via e-mail. For example, vCards include standardized fields such as address and bday (for birthday). With suitable and significant extensions, vCards can be used as the format for the exchange of personal assistant profiles as defined here. A likely although simplistic arrangement would be to pack the requisite information into an unstructured vCard field, such as notes or comments, allowing the vCard mechanism to be exploited to transport profiles.

At a higher level are the personal assistance standards of the Foundation for Intelligent and Physical Agents. FIPA is attempting to standardize some generic aspects of agents, such as a common language and techniques for managing individual agents. FIPA's personal assistance effort looks at the generic activities with a view to ensuring coverage of all potential applications. Preliminary reports describing personal assistance and travel assistance, as well as a general user personalization service defined under the rubric of human-computer interaction, are available at the **FIPA Web site**. ■

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